



**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105**

Via Electronic and U.S. Postal Service Mail

February 2, 2012

Mr. Brian Kelly
Assistant Secretary, Birch / Kraemer, LLC
Chevron Business and Real Estate Services
145 South State College Boulevard
Suite 400
Brea, California 92821

Re: Birch Hills Golf Course, Brea California – “Planning Area 12A Surface Soil Sample and Analysis Plan January 2012. . .”

Dear Mr. Kelly:

Thank you for submitting the *“Planning Area 12A Surface Soil Sample and Analysis Plan January 2012 Birch Hills Golf Course 2250 East Birch Street, Brea, California”* (12A-SAP) dated January 23, 2012 and prepared by URS Corporation for Chevron Land and Development Company (Chevron). The U.S. Environmental Protection Agency Region 9’s (USEPA’s) January 20, 2012 letter to Chevron requested submission of the 12A-SAP for collection of soil samples and analysis of the same for polychlorinated biphenyls (PCBs) and arsenic.¹ The USEPA has reviewed the 12A-SAP for collection of multi-increment soil samples at several decision units in which Area 12A will be subdivided for sampling purposes. USEPA is approving the 12A-SAP with the modifications and conditions presented below.

USEPA Conditions of Approval – Chevron Soil Sampling Plan for Area 12A (12A-SAP)

- 1. Guidance for multi-increment sampling (MIS).** Chevron/URS should follow the attached guidance for multi-increment sampling (MIS).
- 2. Collection of multi-increment soil samples and decision units.** Approximately 30 to 50 increment soil samples should be collected from each decision unit (DU) and at least a minimum of 30 increments (not less). Sample increments must be collected using the sampling equipment specified

¹ During the January 19, 2012, Chevron (Brian Kelly), URS (Jerome Zimmerle), and USEPA R9 (Carmen Santos and Nathan Dadap) discussed the need for additional soil samples and a schedule for Chevron to submit the additional soil sampling plan and for USEPA to approve the plan. Non-PCB contaminants in soils at the Site include among others arsenic and dioxin and furans.

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in the attached MIS guidance. We agree with the DU designations that Chevron/URS have proposed in the 12A-SAP for Area 12A.

3. **Compositing of sample increments.** Rather than compositing the sample increments in the field, the sample increments should be sent to the Chevron/URS contract laboratory for compositing. And before compositing, each soil sample increment should be sieved to a less than 2 millimeter size.
4. **Sample depth.** Our January 20, 2012 letter indicated that soil samples should be collected at 0 to 3 inches below ground surface (bgs). The attached multi-increment sampling guidance states a minimum of 4 inches below ground surface. Chevron may collect the soil increment samples either at 0 to 3 inches or at 4 inches bgs.
5. **Decontamination of sampling tools and movable equipment used during sampling; decontamination residues; and decontamination recordkeeping.** Chevron/URS must decontaminate sampling tools and equipment, and movable equipment being used at the site to facilitate sample collection each time a sample is collected and following the requirements in 40 CFR 761.79(c)(2). Decontamination residues must be disposed at their original concentration in accordance with the requirements in 40 CFR 761.79(g). Recordkeeping of the decontamination conducted under 40 CFR 761.79(c)(2) must be kept in accordance with the requirements in 40 CFR 761.79(f)(2). Decontamination procedures must be implanted in a manner that is protective of human health and the environment consistent with the requirements in 40 CFR 761.79(e).
6. **Waste generated during sampling.** Disposal of personal protective equipment, disposable sampling equipment, and other materials used during sampling activities that have become contaminated with PCBs must be disposed of as required in 40 CFR 761.61(a)(5)(v). If PCB containing soils are generated during sampling at Area 12A, those soils must be disposed following the requirements in 40 CFR 761.61(a)(5)(B) and the chosen disposal method must be based on the as-found (in-situ) PCB concentration.
7. **Reporting of PCB analysis results and extraction methods.** All PCB soil analysis results must be reported as dry weight. In 40 CFR 761 Subpart N, USEPA allows the use of Extraction Method 3540C (Soxhlet) and 3550B (sonication). However, our preferred extraction method is Method 3540C. Our experience is that good extraction performance using Method 3550B is laboratory dependent.
8. **Additional analysis.** In addition to PCBs, the soils to be sampled must be analyzed for arsenic. We understand that Orange County Health Care Agency may require that dioxins and furans be analyzed

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in soils from Area 12A. Chevron/URS must collect soil increment samples of sufficient volume for compositing into one sample for the PCB analysis that is consistent with the attached guidance.

We appreciate Chevron and URS' prompt submission of the 12A-SAP and look forward to its implementation and findings. USEPA appreciates the opportunity to assist Chevron on the redevelopment of Area 12A. Please call Carmen D. Santos at 415.972.3360 if you have any questions concerning this letter.

Sincerely,


for Arlene Kabei
Associate Director
Waste Management Division

Enclosures (1)

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TGM for the Implementation of the Hawai'i State Contingency Plan

Section 4.2

MULTI-INCREMENT SAMPLE COLLECTION

4.2 MULTI-INCREMENT SAMPLE COLLECTION

The HEER Office strongly encourages the use of *Multi-Increment* sample collection strategies to enhance sample representativeness in the investigation of contaminated soil. *Multi-Increment* samples improve the reliability of sample data by reducing the variability of the data as compared to conventional discrete sampling strategies (Ramsey et al., 2005; Jenkins et al., 2005). *Multi-Increment* sample data have much lower variability than discrete sample data and a higher reproducibility. Higher reliability supports greater confidence for decision-making. The theory supporting *Multi-Increment* sampling is based on particulate sampling approaches developed by geologist Pierre Gy to improve the quality of data for mineral exploration and mining (USEPA, 1999c; Pitard, 1993). The approach has been widely used for environmental investigations of nonvolatile chemicals in surface soils, but can also be used for collection of subsurface samples for non-volatile and volatile contaminants. These topics, as well as the use of *Multi-Increment* sampling for stockpile investigations are discussed separately below, following a general discussion of *Multi-Increment* sample collection.

4.2.1 FIELD COLLECTION OF MULTI-INCREMENT SAMPLES

Multi-Increment samples are prepared by collecting a minimum of 30 small increments of soil from a specified decision unit and combining these increments into a single sample, referred to as the "*Multi-Increment* sample." The number of increments incorporated into the field *Multi-Increment* samples, and the overall mass of the *Multi-Increment* samples collected are not dependent on the size of the decision unit. The sampling theory demonstrates that a minimum of 30 increments of an adequate mass from a given decision unit of any size will generally result in a sample that is adequately representative of the average contaminant level in the decision unit as a whole. If the decision unit is the size of a small backyard garden, then a minimum of 30 increments of similar mass are collected. If the decision unit is a 10-acre, neighborhood-size area in a former agricultural field, then a minimum of 30 increments of a similar mass are likewise collected.

Some prefer to increase the number of increments collected to a minimum of 50-100 for large decision units or for DUs where contaminant distribution is expected to be especially heterogeneous. Collection of a greater number increments in each DU would be expected to reduce field sampling error and minimize the variation from the mean among replicate samples used to evaluate representativeness of the data collected (see subsection 4.2.5). The number of increments to be selected for the *Multi-Increment* samples in a site investigation should be evaluated during systematic planning as part of the DQO and

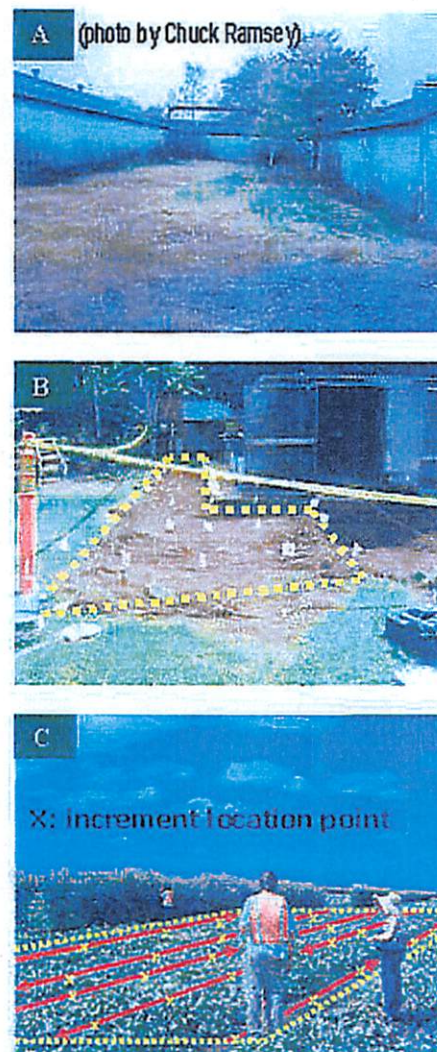


Figure 4-1. Example Decision Units

A) DU used to evaluate direct exposure hazards at industrial site.
 B) DU for spill area contaminated with lead. Flags represent increment locations for confirmation sample collected at bottom of excavation.
 C) DU for hypothetical, residential lot on former agricultural land. Rows and increment collection points start from a single random location, and are

documented in the SAP. Individual soil increments typically weigh between 5 and 50 grams, with field *Multi-Increment* samples typically weighing between 300 and 2,500 grams (mass sufficient to minimize Fundamental Error for sample collection) after sieving soil samples to the target particle size. Note that sieving of soil samples to the < 2mm particle size, typically performed in the laboratory sample preparation process, will reduce the amount of soil mass available for analysis, so this needs to be taken into consideration during systematic planning, particularly during the development of DQO. The mass of the *Multi-Increment* samples depends on the number of increments collected, the depth the samples were collected, the size of the sample collection tool utilized, the total number and type of analyses planned, and the lab digestion/analysis mass required for each test. As discussed below, the mass of the *Multi-Increment Sample* (MIS) could be reduced by sieving (i.e., removal of sticks and stones > 2mm in size) and sub-sampling in the field, prior to submittal to the laboratory.

To collect the sample, a systematic random (preferred in most cases) or stratified random sample collection scheme is utilized. Both these strategies result in the sample collection points being spread out roughly equally across the DU (Figure 4.1). For example, a square-shaped decision unit could be divided into five rows, with six increments collected from each row in a systematic random fashion, with an initial random starting point. For more rectangular-shaped decision units, a fewer number of rows might be used with more increments per row collected. Row lengths and increments per row may be modified as needed for odd-shaped decision units.

It is generally useful to mark the ends of each row with flags to help establish approximate lines for the collection of increments (refer to examples in Figure 4.1). Flags may also be placed along the edges of the decision unit parallel to the rows to help ensure approximate spacing. Although depicted in the Figures, placing flags at every increment collection point is usually not necessary. Often, just the four corners of the DU (or enough points to delineate the DU shape, if irregular) are located via Global Positioning System (GPS) to document the DU location and to create maps for the soil investigation report (GPS location information can be several meters off; this factor should be considered in establishing DQO for the investigation). For a systematic random sample collection, the minimum of 30 individual increment intervals may be determined by "pacing" a set distance on the rows of the DU, and do not need to be individually measured. Typically, the same number of increments (e.g., a minimum of 30) are collected in each DU when sampling multiple DUs on an investigation site, or when collecting replicate samples in a particular DU. For stratified random sample collection, a minimum of 30 approximately equal-sized sub-units would first be established (e.g., a grid established across the DU), then a random location selected in each sub-unit to collect a single increment.

Individual increments collected are placed into a single sample container (Figure 4.2) to produce the MIS. If adequately planned and identified in the DQO/SAP, the *Multi-Increment* samples for non-volatile contaminants may be sieved to the

arranged in a manner that ensures a minimum of thirty increments are collected across entire DU.



Figure 4-2. Sample Increment Collection

Collect an "increment" of soil at each point. In this example (very soft soils), a small pick is used to loosen a cylindrical volume of soil to a depth of approximately 10cm. A trowel is then used to collect the increment in a core-like shape and place it into a temporary container, in this case a clean, paper bag. Each increment typically weighs 5 to 50 grams. Subsequent increments are placed in the same container.



Figure 4-3. Sample Processing in Field

Sieve each *Multi-Increment* sample to <2mm (optional in field). This removes sticks, rocks and other large particles and decreases the mass of the sample sent to the laboratory. This also helps ensure an adequate mass of sample of appropriate particle size is collected. However, samples are more commonly dried and sieved at the laboratory.

<2mm particle size in the field to remove large particles and reduce sample mass (Figure 4.3). In some cases, sieving samples in the field could be difficult due to a high moisture content of soils or lack of adequate field facilities, appropriate equipment, or planning. Generally, laboratory processing of the field samples is preferred, due to the more "controlled" working environment, where sieving is facilitated by initial air-drying of the samples.

The <2mm sized soil particles are generally considered "soil" and of most interest for contaminant analysis (at least for an initial analysis), while larger particles are considered gravel, rocks or other materials (e.g., sticks and roots). Sieving the soil sample to the <2mm size also establishes the maximum particle size of the sample, which is necessary to determine the minimum sample mass necessary for extraction/analysis in the laboratory (see Section 4.2.2). Although sieving to the < 2mm particle size is typical, there may be contaminant investigations or analyses where alternate particle sizes may be of interest. In these cases, the rationale for sieving to other specific particle sizes (and associated changes to lab processing/analysis) should be clearly discussed in the DQO/SAP.

A field-sieved sample may be sub-sampled in the field for mass reduction, or the entire sieved MIS may be sent to the lab for processing and sub-sampling before analysis. If sub-sampled in the field, the entire sieved sample is spread out to a thin layer (~0.25 inch thick), and sub-sampled in a manner similar to how the field *Multi-Increment* sample was collected – by taking approximately 30 increments in systematic random locations across the (spread-out) sample (Figure 4.4). In this case, sub-sampling would be conducted with a small rectangular shaped scoop.

Simply dividing a *Multi-Increment* sample (sieved or not) into separate volumes and placing each volume into separate sample containers for analysis is not an acceptable method of mass reduction. Likewise, samples "homogenized" by mixing in the process of sub-sampling in the field or lab may just serve to further segregate different particle sizes in the sample rather than mixing them as desired, because particles may settle in layers by weight or size during mixing. The process of spreading the entire sample out to a thin layer and collecting many increments in a systematic random fashion (with a small tool that can scoop to the bottom of the sample) provides the best means of collecting a representative sub-sample of all the different sizes and types of soil particles present in the *Multi-Increment* sample.

4.2.2 LABORATORY PREPARATION OF MULTI-INCREMENT SAMPLES

The field *Multi-Increment* sample is submitted to the laboratory for processing and analysis. Alternately, a sample is submitted to the lab that has been sieved to <2mm, or sieved and sub-sampled to reduce mass in the field, if planned as part of the DQO/SAP for the site investigation. In the laboratory, the MIS (for non-volatile analyses) is typically air dried and sieved to <2mm. Contaminant analyses of all soil samples (regardless of how they were collected) are required to be reported on a dry weight basis (if samples are air dried and sieved prior to analysis, resulting analyses would be considered dry weight analyses). In some cases, such as for lead or bioaccessible arsenic analyses, both the <2mm and the "fines" particle size fraction (<250 µm) may be analyzed



Figure 4-4. Obtaining Subsamples in the Field

Use *Multi-Increment* approach to subsample initial field sample, if needed. This reduces the mass of sample sent to the laboratory. Thirty to fifty increments of roughly equal mass are collected and placed into the final sample container. Sub-sampling is more commonly conducted in the laboratory.



Figure 4-5. Obtaining Subsamples in the Laboratory

The laboratory air-dries and sub-samples the *Multi-Increment* sample. Approximately 30 increments are collected. The mass of each increment is based on the total mass of sample needed for the relevant analyses (typically a minimum of 10 grams).

(see [Section 9](#) and [Section 12](#)). In the lab, sub-sampling is accomplished either with a sectorial splitter (also called a rotary riffle splitter, this sub-sampling method is generally considered best), or a representative subsample is hand collected by taking ~ 30 small increments from systematic random locations from the dried and sieved sample spread out to a thin layer ([Figure 4.5](#) and [Figure 4.6](#)). Sub-sampling is used to provide a representative laboratory sub-sample (and any lab replicates) for a single *Multi-Increment* sample, and to provide representative sub-samples for multiple analyses. The mass of sample needed for the subject analytical test or tests is used to determine the parameters for splitting the sample with the sectorial splitter, or in selecting the mass of each increment if hand collecting the sub-sample. In either case, it is critical that the entire mass of dried and sieved sample is utilized for the sub-sampling process.



Figure 4-6. Use of a Sectorial Splitter to Collect Subsamples
Sectorial splitter (rotary riffle splitter) to collect lab subsamples of the dried and sieved *Multi-Increment* sample for analysis. If a sectorial splitter is not available, then collect separate, *Multi-Increment* subsamples of appropriate mass for each analysis from the entire available mass of the sieved sample.

The Gy sampling theory, which is the foundation of the *Multi-Increment* sampling approach, is also the basis of two primary references on laboratory sub-sampling and analysis of particulate samples: United States Environmental Protection Agency ([USEPA, 2003b](#)) and American Society for Testing and Materials ([ASTM 2003](#)). These are recommended as lab guidance by the HEER Office. Of all the steps necessary to process and analyze environmental samples, lab sub-sampling is widely believed to present the greatest potential for error. The lab sub-sampling guidance applies to all types soil samples collected in the field, whether *Multi-Increment*, discrete, or judgmental samples.

One issue discussed in both the USEPA and ASTM guidance documents is the choice of a minimum sub-sample mass for extraction/analysis of soil samples in order to reduce "Fundamental Error" of the lab analyses to approximately 15% or less, which is also recommended by the HEER Office as a primary lab data quality objective. The minimum appropriate mass is based on the maximum particle size in the soil samples. For samples with a maximum particle size of <2mm, the minimum analysis mass is 10 grams. This is a minimum analysis mass; there could be cases where this mass is not sufficient to reduce error. In general it is preferable to increase the minimum analysis mass if possible, to reduce opportunity for error. If the analytical method to be used typically calls for sample extraction/analysis mass of less than 10 grams, the laboratory should be consulted on modifying the method to increase extraction/analysis mass to at least 10 grams for samples with maximum particle sizes of <2mm (larger mass could be beneficial for some analyses). For analyses of fine particulates (e.g., <250 μm), a one-gram sub-sample may be adequate to reduce Fundamental Error below 15%; however if a larger mass may be reliably run by the method (e.g., 2-10 grams), the HEER Office recommends using a larger mass to help reduce opportunity for error. In cases where labs will not modify methods to allow larger sample masses to be extracted and analyzed (this is primarily an issue for metals analyses), the HEER Office should be consulted for options (e.g., grinding, as described below).

Grinding soil samples to achieve very uniform small particle sizes is an option to reduce Fundamental Error and the extraction/analysis mass for certain (non-volatile) contaminants. For example, a USEPA SW-846 method for processing and analyzing energetic compounds calls for grinding the samples to meet data quality objectives (this method also includes guidance on field *Multi-Increment* sampling for energetic compounds ([USEPA, 2006d](#))). Grinding of samples also reduces the potential for segregation error. However, suitable grinders are expensive and not many labs offer this service as yet (consult the HEER Office for recommendations on labs that can grind samples appropriately). Grinding a sample may not be appropriate for some situations such as samples being analyzed for bioaccessibility/bioavailability; the use of this option will also depend on the site investigation DQO.

4.2.3 COLLECTION OF FIELD REPLICATE *MULTI-INCREMENT* SAMPLES

To statistically evaluate sampling precision for each DU, additional, completely separate replicate *Multi-Increment* samples (collected from a set of systematic random or stratified random locations within the DU that

are different from those used for the initial *Multi-Increment* samples) are collected from selected decision units. The replicates are made up of a minimum of 30 different systematic or stratified random increments from within the same DU. The replicate samples are prepared and analyzed in the same manner as carried out for the initial sample. Triplicate samples (i.e., initial MIS plus two replicates) are preferred and more useful than just duplicates for statistical evaluation.

If only one DU is being investigated, a triplicate sample is recommended for evaluation. For sites with a number of similar DUs, "batch" type replicates can be used - for example a triplicate sample in one DU to provide data for evaluating precision for up to 10 similar DUs (similar to how labs use batch replicates for determining lab analysis precision). Each site will be unique in terms of numbers of DUs and how similar these DUs are, so decisions on numbers of replicates are unique to each site and should be addressed clearly in the SAP.

A different random starting location is determined for each replicate collected in the selected DU(s). Replicate sample increments are generally collected along the same approximate directional lines established through the DU for the initial *Multi-Increment* samples, though at different systematic random locations than initially used. This is accomplished by pacing off the replicate increments from a different random starting location on the first line/row of the DU, and continuing to sample at this different random interval throughout the DU. The replicate increments should not be collected from the same points or co-located with those used for the initial *Multi-Increment* samples. Replicate samples are sent to the laboratory as "blind" samples, meaning the laboratory does not know they represent replicate samples of the initial *Multi-Increment* samples. A discussion of the statistical approach for evaluating replicate *Multi-Increment* samples is provided in [Section 4.2.5](#).

4.2.4 FIELD TOOLS FOR THE COLLECTION OF MULTI-INCREMENT SAMPLES

A detailed discussion of field sampling tools is provided in [Section 5](#). Care should be taken to collect increments in a manner that produces a cylindrical or core-shaped sample. This can be accomplished using a soil coring sampler (preferred), a trowel (if used to collect a "core-shaped" sample over the entire depth of interest), or even a large drill in some soils. Using the wrong tools, or collecting a sample that contains more soil particles from the top of the sample than the bottom (or vice versa) could lead to biased sample results due to the heterogeneous distribution of contaminated particles in the soil.

The most appropriate type of sampling device is dependent in part on the hardness of the soil, or how rocky it is. For soft soils, an approximately one-inch diameter soil core barrel that can be advanced by hand/foot is quick and efficient. Battery-operated drills with large bits may also be an option. For harder or rocky soils, a coring device with slide hammer, a mattock (large pick), hydraulic, or electric-assisted device, may be needed to advance the core barrel or access the soil column for sampling. Whatever tool(s) used, the objective should focus on collecting core-shaped sample increments. As discussed in [Section 5](#), it is important to understand field conditions and test proposed sampling tools at the site before selecting a particular type or combination of tools. If the site cannot be visited ahead of time, then a mix of sampling tools should be taken to help ensure that adequate soil samples can be collected in as efficient a manner as possible.

4.2.5 STATISTICAL EVALUATION OF REPLICATE MULTI-INCREMENT SAMPLES

When field sampling is "representative," repeat measurements within the same DU would be expected to estimate the average contaminant concentration similarly. Data from replicate sampling ([Section 4.2.3](#)) are used to determine:

1. The amount of variation from the mean that will be considered when comparing average contaminant concentrations in the DU to applicable HDOH environmental action levels (EALs)
2. Whether the estimate of average contaminant concentration(s) is adequately representative for the DU(s) under investigation, per the established DQO (see [Subsection 4.2.5.3](#))

Criteria for the statistical evaluation of the MIS data need to be part of the DQO for the site investigation.

There are a number of options available for determining what measure of data variation from the mean will be used when evaluating the *Multi-Increment* sample replicate measurements and comparing *Multi-Increment* sample data to applicable HDOH EALs. The measure of data variation from the mean that is chosen is a function of the DQO for the site investigation. Two common approaches are: 1) use of the standard deviation of the replicate values, or 2) use of the 95% Upper Confidence Level of the replicate (triplicate) values. These are described further in subsections below.

4.2.5.1 STANDARD DEVIATION

Standard deviation is a well known measure of the variation from the mean among a group of samples, and in this case it can be determined for triplicate samples taken in one or more DUs. The lower the standard deviation (the closer the replicate data are to the mean) the more precise the site data are as an estimate of average contaminant concentration in the DU under investigation.

For example: If the average concentration of field replicates for a given contaminant under investigation in the DU is 5 mg/kg, and the standard deviation is 1, then the estimated average concentration with consideration of variation from the mean resulting from the total error (field sampling/processing error + lab sub-sampling/processing error + lab analysis error) would be a range of 4 - 6 mg/kg. The upper end or the mean plus the standard deviation, 6 mg/kg, would be selected to evaluate whether the average contaminant concentration is above or below the relevant HDOH EAL.

Where replicate sampling is used to evaluate the variation from the mean of multiple DUs, (e.g., replicates collected in one DU to represent a "batch" of similar DUs) the standard deviation of the contaminant(s) in the selected replicate DU is added to the contaminant levels of the other DUs in the batch for comparison to the relevant HDOH EAL(s).

4.2.5.2 95% UPPER CONFIDENCE LIMIT

An alternative to using the standard deviation to evaluate variation of the replicate (triplicate) samples from the mean is to calculate the 95% Upper Confidence Limit (95% UCL) of the arithmetic mean as follows:

$$95\% \text{ UCL} = \text{arithmetic mean} + \frac{95\% \text{ one-sided student t factor} \times \text{standard deviation}}{\text{Square root of the number of (replicate) samples}}$$

The student t factor is taken from a statistical table; if the number of (replicate) samples is 3, the 95% one-sided student t factor = 2.92. The 95% UCL of the arithmetic mean for the contaminant(s) in the replicate DU would be used for comparison to the relevant HDOH EAL. This 95% UCL formula assumes contaminant data approximate a normal distribution (see subsection below).

For a DU where replicates collected in one DU are used to evaluate the variation from the mean of multiple DUs, the

$$\frac{95\% \text{ one-sided student t factor} \times \text{standard deviation}}{\text{Square root of the number of (replicate) samples}}$$

factor of the 95% UCL formula for the contaminant(s) in the replicate DU would be added to the MIS results for the other DUs in the batch to determine the concentration for comparison to the relevant HDOH EAL.

Use of either the standard deviation or 95% UCL statistic is generally acceptable to the HEER Office to determine sample data variation from the mean based on triplicate MIS in selected DUs. In some cases, the DQO/SAP may specify use of an alternate approach to measure and evaluate variation from the mean in replicate sample data – these alternatives should be clearly identified and discussed with a HEER Office project

manager for use in the site investigation.

4.2.5.3 EVALUATION OF REPLICATES AND DATA REPRESENTATIVENESS

The field replicate data collected for DUs are also used to demonstrate that the investigation error for each contaminant is within a reasonable range that supports a conclusion that average contaminant concentrations (e.g., mean plus standard deviation or 95% UCL of the mean) is below or above the relevant HDOH EAL, as identified in the site investigation DQO. In other words, this evaluation addresses the question of whether the data are good enough to make a decision that an average contaminant concentration is below or above the HDOH EAL.

Typically, the Relative Standard Deviation (RSD) of the field replicates (triplicates) is used for this evaluation. The RSD is expressed as a percentage and is calculated using the following formula:

$$\text{RSD} = \frac{100 \times \text{Standard Deviation}}{\text{Average}}$$

The lower the RSD% of the replicate data the better. Generally, an RSD% of approximately 35% or less indicates the amount of estimated total error is within a reasonable range for decision-making. However, this evaluation will also depend on the DQO established for the site investigation, as well as how close the contaminant concentrations are to the relevant HDOH EAL(s). For example, if the RSD% of replicates for a contaminant concentration in a DU was determined to be 40%-50%, but the contaminant concentration was a factor of 3 or 4 below the relevant EAL, then a decision that the contaminant is below levels of concern would still be valid. In general, the closer the contaminant level is to the HDOH EAL, the more impact this statistical measure will have on site decisions.

The *Multi-Increment* sampling approach provides averages that approximate a statistically "normal distribution" if the RSD% of replicates is reasonably low (this is assumed, for example, when determining the 95% UCL of replicate data, as discussed in [Subsection 4.2.5.2](#)). The higher the RSD%, the less confidence there is that the averages approximate a normal distribution, and that the average contaminant concentrations are adequately representative of the DU(s). As the RSD exceeds 50%, and if the average DU concentrations are near the relevant action levels, there is increasing uncertainty that the data are adequately representative. In this case additional *Multi-Increment* sampling may be necessary, utilizing a larger number of sample increments and/or larger sample increment masses to obtain a more representative measure of the (very heterogeneous) contaminant concentrations in the DU. Careful evaluation of the sample processing and analysis procedures would also be indicated. In some cases, grinding samples may serve to reduce the RSD% and provide more representative sampling data.

As the RSD% approaches 100% there is very little confidence that the sampling data is useful for decision-making. (Note: in the case where estimated average concentrations of replicate data are all above the relevant action levels, even if the RSD% is high, a decision supporting additional response action may be warranted). The HEER Office can be consulted on follow-up options or interpretative advice for DU's where the RSD% of replicate samples exceeds the site investigation DQO.

4.2.6 COLLECTION OF SUBSURFACE MULTI-INCREMENT SAMPLES

See also the [Use of Decision Unit and Multi-increment Soil Sample Investigation Approaches to Characterize a Subsurface Solvent Plume document](#) in the "Additional Guidance Documents".

The following circumstances are examples of when it would be necessary to delineate the vertical distribution of non-volatile contaminants in soil:

- Contaminants in surface soils are found to exceed HDOH EALs

- The land is being evaluated before site preparation, and it is unclear what depth of soil will end up at the surface (where most potential exposure is expected to occur)
- To identify any potential problems with moving or disposing soils offsite
- To determine the potential for contamination of specific areas where exposures to deeper soils may be expected (e.g. planned garden areas, excavation areas for utilities)
- Contaminants are suspected to have leached to subsurface soils or toward groundwater

It is generally more challenging to collect *Multi-Increment* samples for non-volatile contaminants from subsurface soils than from surface soils. On sites where mechanical excavation equipment can be readily used to access subsurface soils, this is oftentimes a good approach. If a coring device is used, then it may be feasible to collect separate increments from targeted depths at each increment collection location (e.g., 12-18 inches, 18-24 inches, etc.) Vertical soil increments for MIS (or other types of soil samples) generally do not exceed 6 inches in depth, especially for surface soils or near surface soils, though deeper sampling intervals are not uncommon at greater depths, and this is a site-specific decision to be addressed in the site investigation DQO. Increments from the same depth in separate increment locations are placed in a common container and used to create a single, *Multi-Increment* sample representative of that depth. This will generate MIS data for specific depths in the decision unit.

If the soil is relatively soft and available coring tools allow ready access to surface and subsurface soils, then subsurface MIS should be collected with the typical minimum of 30 increments. Similarly, if the site is accessible to mechanical equipment and it is possible to use a minimum of 30 small excavations/pits across the site, the MIS approach may be applied by sampling excavation sidewalls at successive depths (or at the specific depth(s) of interest), (see [Figure 4.7](#)). Data for each *Multi-Increment* sample is used to generate a three-dimensional map of soil contaminated above HDOH EALs in the decision units.

On certain sites, installing a minimum of 30 cores, borings, or small excavations to depth(s) in each DU may not be feasible or practicable due to access or cost constraints, and reducing the number of increments collected for the MIS in the DU(s) may be the only option available. If this is the case, it is also important to recognize that collection of a reduced number of sample increments is likely to reduce data quality and may affect



Figure 4-7. Collecting Subsurface *Multi-Increment* Samples
Use of shallow pits dug by a backhoe to expose soil in decision units and collect separate, *Multi-Increment* samples at targeted depths.

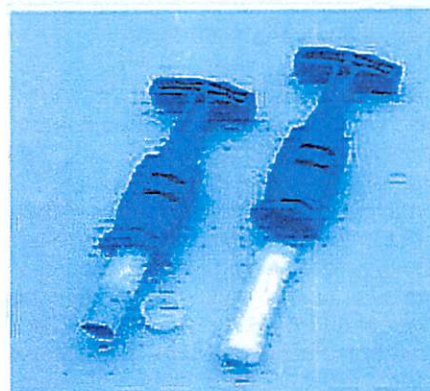


Figure 4-8. Coring Device for Soil Increment Collection
Example of coring device for collecting soil increments to be tested for volatile contaminants (Core N' One™ tool). Increment is extruded from sampler after collection and placed in a container with a preservative (typically methanol).



attainment of DQO for the site investigation. Consequently, in these circumstances careful review of DQO as well as any other sampling options that may be available is warranted. A HEER Office project manager may be consulted whenever constraints limit ability to collect at least 30 increments for MIS in subsurface decision units. The subsurface sampling strategy chosen, the sampling constraints, and potential impacts on data quality should also be identified in the DQO/SAP.

4.2.7 MULTI-INCREMENT SOIL SAMPLE COLLECTION FOR VOLATILE ANALYSES

See also the Use of Decision Unit and Multi-Increment Soil Sample Investigation Approaches to Characterize a Subsurface Solvent Plume [document](#) in the "Additional Guidance Documents".

Multi-Increment soil samples can also be collected for volatile contaminant analyses from cores, excavation bottoms and walls, stockpiles, and underneath paved areas. Volatiles are not typically sampled in surface soils.

The approach is similar to that described for sampling non-volatiles in the sub-surface, except that the multiple soil increments are placed in an extraction solution in the field (i.e. methanol). A volume of methanol large enough to accommodate the multiple increments of soil is necessary, so close coordination with the laboratory is important. If the larger volume of methanol presents problems for shipping (especially for sites not on O'ahu) alternatives can be considered in consultation with the laboratory. With procedures and protocols in place ahead of time, the larger volume of methanol could be sub-sampled for shipment, or individual increments could be collected in separate sampling devices that have vapor tight seals and are designed for zero headspace (e.g. Core N' One, EnCore, or equivalent type sampler) and submitted to the laboratory within appropriate time frames for combined placement in methanol before analysis.

Guidance on *Multi-Increment* sampling for volatiles was published by the Alaska Department of Environmental Conservation in 2007 ([ADEC, 2007](#)). It is recommended that consultants provide a sampling and analysis work plan to the HEER Office for review and comment prior to collecting *Multi-Increment* samples for volatile analysis. The analytical laboratory should also be consulted prior to sample collection to discuss sample containers, sample handling, preservative type and volume, shipping of samples in methanol, anticipated laboratory method detection limits, etc. A potential drawback of *Multi-Increment* sampling for volatiles is that method detection limits (MDLs) could be above relevant HDOH EALs for certain targeted chemicals. If the MDL or other issues present difficulties in using MIS for volatiles, this should be discussed with the laboratory and the HEER Office prior to sample collection. If projected MDLs are too high to be of use, or some other issue restrains the use of these methods at a specific site, then alternative approaches may need to be used. As noted in [Subsection 4.2.6](#), collection of only a limited number of increments (e.g., < 30) may need to be considered at some sites due to difficulties and /or costs associated with subsurface sampling (especially at greater depths or in



Figure 4-9. Collecting Soil Increments from a Split Spoon Sampler

Collection of soil increments to be tested for VOCs. (photos provided by A. D. Hewitt, C.A. Ramsey and S.R. Bigl)



Figure 4-10. Methanol Containers for Volatile Samples

Increments are placed in a container with an equal mass of methanol.

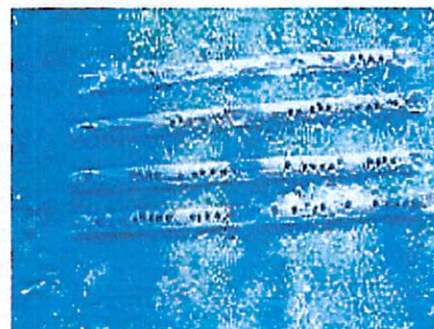


Figure 4-11. Soil Cores Multi-Increment-Sampled

Core after collection of *Multi-Increment* sample (photo provided by A. D. Hewitt, C. A. Ramsey and S. R. Bigl).

certain soils), but reduced numbers of increments is likely to reduce data quality, so the site investigation DQO and sampling options should be carefully reviewed.

Distinct spill areas are typically associated with the release of volatile organic chemicals. If the chemical poses potential vapor intrusion, leaching or gross contamination hazards, as is common for volatile contaminants, then the spill areas in general should be treated as separate decision units (see [Section 3](#)). *Multi-Increment* sample points are established in the same manner as discussed above; a minimum of 30 increments are collected in each decision unit. Example decision units include an area of obvious staining and the walls and floor of an excavation. In some cases each side wall and floor of an excavation area may be separate decision units, or the floor of an excavation could be divided into more than one decision unit to evaluate a more specific area where contamination may have migrated. In other cases, certain side walls or all the side walls may be combined into a single decision unit. The rationale for selecting DUs within an excavation should be clearly addressed in the DQO/SAP for the site investigation.

Increments should be collected using tools that minimize the loss of volatile chemicals during sample collection and allow the collection of at least a five-gram mass of soil. Syringe-type devices that can be pushed directly into the soil are preferable. An example is the Core N' One™ tool depicted in [Figure 4.8](#). These types of devices (available in different sizes) can also be used for the collection of samples to be tested for nonvolatile chemicals (see [Section 5](#)). The device is pushed into the soil, retracted, and the increment collected is immediately extruded into a container with a premeasured volume of preservative (e.g. methanol). This is repeated with each increment. Sampling devices should be decontaminated or disposed of between decision units.

A minimum of a 1:1 ratio of sample preservative to sample soil (i.e., 1 milliliter of methanol to 1 gram of soil) is recommended. Additional preservative may be required to ensure the sample mass is completely submerged by the preservative. This should be discussed with the laboratory that will receive and analyze the samples. To select the appropriately sized sample container, consideration should be given to the total volume of soil to be collected and preservative required (e.g., 30 increments of 5 gram volume each would provide an approximately 150 gram volume and require approximately 150 milliliters of preservative). Utilize a container that is large enough to accommodate additional preservative (if needed) and to prevent loss of preservative through splashing (as soil increments are dropped into the container).

Similar types of devices can be used to collect *Multi-Increment* samples from boring cores. As the zone targeted for the collection of *Multi-Increment* samples is identified and increments collected at regular intervals ([Figure 4.9](#)), increments are placed directly into a container with a preservative ([Figure 4.10](#)). As shown in [Figure 4.11](#), this approach provides a much better coverage of the core than a single discrete sample. The collection and analysis of a single *Multi-Increment* sample also significantly reduces lab costs in comparison to multiple discrete samples. Another sub-sampling approach is to slice a wedge or portion of the core down the entire length of the vertical increment of interest.

Soil gas data are also highly recommended for characterization of sites contaminated with volatile chemicals, and may be more appropriate for some site investigations than soil sampling. Soil gas data are much more reliable than soil data for evaluating potential vapor intrusion hazards associated with volatile contaminants in soil (and groundwater). Soil gas data are also very useful for identifying and locating areas of heavy contamination. Refer to the HDOH guidance document *Evaluation of Environmental Hazards at Sites with Contaminated Soil and Groundwater* ([HDOH, 2008](#)) and [Section 7](#) of this guidance for additional information.

4.2.8 COLLECTION OF MULTI-INCREMENT SAMPLES FOR STOCKPILES

Multi-Increment sampling is the recommended method for characterizing soil stockpiles. Approaches similar to those described in [Sections 4.2.1](#) through [4.2.7](#) should be used. If volatile contaminants are being sampled, increments should be collected from depths greater than 6 to 12 inches below the surface of the pile.

Special considerations for selecting DUs for sampling soil stockpiles include:

- The source of the soil in the stockpile

- How the stockpile was created (over time, if applicable)
- How best to access the pile for sampling, especially if it is large and or unstable
- What contaminants should be targeted for lab analyses

To the extent that background information is available to address these or related issues, it should be obtained, examined and included in the SAP for the stockpile sampling.

One of the best options in certain cases is to coordinate sampling with the formation of any stockpiles on the site. When the stockpile is being formed there is generally good access to sampling each portion of the pile over time, and ensuring access to the entire stockpile DU is provided for good sample representativeness. If an existing stockpile is relatively small, good options may be to have the pile moved and take the MIS increments while it is being moved (e.g., from the front-end loader buckets, at appropriate intervals), or to flatten or spread out the stockpile sufficiently so that it is safely accessible to sample with a hand coring (or other) device.

If the stockpile is very large or unstable, all available sampling tools (see [Section 5](#)) or methods that safely provide access should be considered, with the goal of coming as close as possible to collecting a minimum of 30 systematic-random or stratified-random samples throughout the stockpile (both vertical and horizontal locations). Replicates are important to evaluate the precision of stockpile sampling, and should be collected similarly to the original sample except in separate random locations. Large stockpiles could be broken or segregated into separate DUs, especially if it is known that a specific portion or volume of the stockpile will be used in a manner that will become the primary exposure unit of concern in the future (e.g., certain portions or volumes of the stockpile will be hauled to residential lots as surface fill for backyards).

Where access and/or safety issues are significant concerns in collecting appropriate MIS for stockpiles, the HEER Office should be consulted on options for alternate sampling plans.

4.2.9 MULTI-INCREMENT SAMPLING FOR SITE CHARACTERIZATION VERSUS SITE REMEDIATION

The objectives of *Multi-Increment* sampling for initial site characterization are typically distinct from *Multi-Increment* sampling aimed at making decisions on subsequent site remediation (if applicable). After selection of DUs at the site, initial sampling focuses on obtaining the average concentration in each DU for comparison to the appropriate HDOH EAL. Then, only in those DUs where a potential exposure risk has been identified (i.e., an HDOH EAL exceedance) and where an Environmental Hazard Evaluation substantiates a significant hazard at the site, may additional MIS for remediation purposes be appropriate.

If a significant exposure hazard has been identified in one or more DUs and it is relatively easy and cost effective to remove the contaminated soil, no additional sampling would generally be conducted and the soil just removed to an approved landfill. However, if the contaminated area is large and/or removal very expensive, additional sampling in portions of the contaminated DU(s) may serve to identify large spill areas or specific areas of the site that have generally higher or lower concentrations than other areas. If identified, this information may be helpful for initial removal actions and to help establish DU boundaries for subsequent *Multi-Increment* sampling (see specific examples for soil arsenic investigations given in [subsection 4.3](#)). It is important to note that *Multi-Increment* or discrete sampling to assist remediation decisions is generally more complex than *Multi-Increment* sampling for initial site characterization. Consequently, these investigations will be site-specific and should be carefully planned and coordinated with the HEER Office.

Interim Final-November 12, 2008